COUPLED MODE PROBLEMS FOR BOTTOM INTERACTING SOUND

and

COUPLED MODE PROBLEMS FOR BOTTOM INTERACTING SOUND: STUDENT SUPPORT (AASERT)

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LONG-TERM GOALS

The long-term goal of this research is to improve our ability to model and predict VLF acoustic propagation in shallow water with particular emphasis on the range dependence of the medium and the geoacoustic properties of the bottom, and to quantify the various factors affecting the overall acoustic energy budget in shallow water propagation.

SCIENTIFIC OBJECTIVES

Our scientific objectives are to incorporate the effects of sediment anisotropy, strong sediment attenuation, and the effects of both deterministic and stochastic medium properties into a local coupled mode propagation model, and to develop accurate theory and robust numerical algorithms for the shallow water propagation problem.

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APPROACH

We are using an approach based on coupled local modes to carry out a systematic study of the effects of scattering, normal dispersion, transverse isotropy and intrinsic attenuation on a propagating shallow water acoustic signal with strong bottom interaction. The coupled mode theory is developed from the first order equations of motion for the stress and displacement rather than from the second order equations for a coupling coefficients depending on the second-order derivatives with respect to the range coordinate of the local modefunctions. These second order coupling coefficients are an artifact of t he formulation, and not present in the coupled mode theory based on the first order equations of motion.

WORK COMPLETED

The code to compute time domain seismo-acoustic signals in a range dependent 2-D shallow water waveguide including transversely isotropic sediments was completed by Minkyu Park and R. Odom. Theory to incorporate randomly rough boundaries into the seismo-acoustic coupled mode code was completed by Minkyu Park and R. Odom. Coding of the energy diffusivity functional was completed by undergraduate student Valerie Peyton, R. Odom, and J. Mercer. Incorporation of local mode code including more general seidment anisotropy was begun by grad student Darin Soukup and R. Odom.

RESULTS

Time domain signals show clear evidence of mode coupling in a range dependent waveguide, and sediment transverse isotropy tends to suppress the mode coupling somewhat. Roughness at the water-sediment interface causes Scholte waves to be strongly coupled to other waveguide modes (Odom et al., 1996, Park and Odom, 1997a). The coupled mode propagator in range dependent lossless media is unitary. The unitarity of the propagator implies that the propagation process can be thought of as a rotation in anabstract vector space comprising the range varying local bases. The coupled m ode propagator for the range dependent medium with rough interface boundaries satisfies a Lippman-Schwinger type integral equation. We have solved the L-S equation in approximation and computed the scattering attenuation for a representative shallow water waveguide (Park and Odom, 1997b). The scattering attenuation peaks when the horizontal modal wavelength is approximately equal to the correlation length scale of the boundary roughness. This is a bit like Bragg scattering in a random medium.The energy diffusivity exhibits strong dependence on the horizontal mode slowness, which indicates that even in strongly scattering waveguides there may be some signal coherence. (Peyton, Odom and Mercer, 1996)

IMPACT ON SCIENTIFIC OBJECTIVES

The development of our mode coupling code for fluid-elastic media and our theoretical work on energy diffusion indicate steady progress towards meeting our scientific objectives. This research is directly applicable to predicting the acoustic field in a complicated range dependent shallow water waveguide.

TRANSITIONS

Modal methods for modelling in random range dependent shallow water wave guides should provide important constraints on the most significant waveguide properties affecting propagation at low frequencies.

RELATIONSHIP TO OTHER PROJECTS

Our research is directly related to other programs studying surface, volume and bottom interaction effects, and is also of relevance to mine countermeasures programs.

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